

CVP Cost Allocation Study

November 19, 2013

Description of Analytical Tools

Name

Statewide Agricultural Production Model (SWAP)

Availability of Technical Support

A summary of SWAP documentation is available on SWAP web site:

<http://swap.ucdavis.edu/>

Categories

Optimization of crop acreage

Main Features and Capabilities

- *Yearly* time step
- Spatial scale (27 regions comprising the Central Valley of California based on local hydrology and DWR's Detailed Analysis Units (DAU))
- SWAP considers 20 crops
- SWAP projects future cropping patterns, land use, and water use by considering land and water availability and their costs, market conditions, and production costs.
- The model selects those crops, acreage and water supplies that maximize profit subject to certain constraints.
- Constraints include availability of land, labor, water and supplies.
- SWAP uses Positive Mathematical Programming (PMP) technique to incorporate both marginal and average economic conditions when maximizing profit.

Applications

SWAP is an extended and improved version of Central Valley Production Model (CVPM). The older CVPM has already been applied in the past Water Plan Updates to forecast future crop acreage for the of the Central Valley regions. Though the current SWAP has not yet been used to forecast future crop acreage, but it has been tested with past historical data for the purpose of calibration and verification.

Calibration/Validation/Sensitivity Analysis

Calibration refers to the calculation of some model parameters in such a way that the model will predict a given set of target data. The SWAP is calibrated against irrigated acreage by crop and by region.



An innovation in the SWAP model over the CVPM model and related PMP models is the use of exponential cost functions. The exponential form of the cost function has several advantages over the more frequently specified quadratic cost function. The most important practical advantage is that the exponential cost function is better able to fit a desired elasticity of supply without forcing the marginal cost of production of the initial unit to assume unrealistic values.

Peer Review

Although PMP technique has been published in refereed journals, no official Review of SWAP has been conducted.

Anatomy of SWAP

Conceptual Basis

Conceptually, SWAP is an agricultural crop acreage model that simulates the decisions of agricultural producers (farmers) on a regional level based on principles of economic optimization. The model assumes that farmers maximize profit subject to resource, technical, and market constraints. Farmers sell and buy in technical and institutional constraints.

Theoretical Basis

Traditional optimization models such as linear programming rely on data based on observed average conditions (e.g., average production costs, yields, and prices), which are expressed as fixed coefficients. As a result, these models tend to select crops with highest average returns until resources (land, water, and capital) are exhausted. The predicted crop mix is therefore less diverse than observed in reality. The most widespread reason for diversity of crop mix is the underlying diversity in growing conditions and market conditions. Simply put, any crop-producing region includes a broad range of production conditions. All farms and plots of land do not produce under the same, average set of conditions. Therefore, the marginal cost and revenue curves do not coincide with average cost and revenue curves. To account for crop diversity, SWAP has been formulated on the basis of marginal (incremental) conditions.

Numerical Basis

Numerical basis of SWAP is a technique called Positive Mathematical Programming (PMP) which incorporates both marginal and average conditions. In the conventional case of diminishing economic returns, productivity declines as output increases. Therefore, the marginal cost of producing another unit of crop increases as production increases and the marginal cost exceeds the average cost. The PMP technique uses this idea to reproduce the variety of crops observed in the data. Several possible or combined reasons for crop diversity are: diverse growing conditions that cause variation in production costs or yield; crop diversity to manage and reduce risk; and constraints in marketing or processing capacity. SWAP assumes that the diversity of crop mix is caused by factors that can be represented as increasing marginal production cost for each crop at a regional level. For example, SWAP costs per acre increase for cotton farmers as

they expand production onto more acreage. The PMP approach used in SWAP uses empirical information on acreage responses and shadow prices—implicit prices of resources—based on standard linear programming techniques and a calibration period data set. The acreage response coefficients and shadow prices are used to calculate parameters of a quadratic cost function that is consistent with economic theory. The calibrated model will then predict exactly the original calibration data set, and can be used to predict impacts of specified policy changes such as changes in water supplies.

Input and Output

Main categories of inputs and outputs in SWAP are as follows. Inputs: (Water supply by source, Crop unit water use (ETAW), Ag water use efficiency, Crop production function, Crop yield, Crop demand information, Crop price, Cost of water, Cost of groundwater pumping (energy cost), groundwater pumping depths and lifts, Farm policy) Outputs: (Crop acreage by region, Ag water use by region, Crop revenues, Producers profit, Consumers surplus)

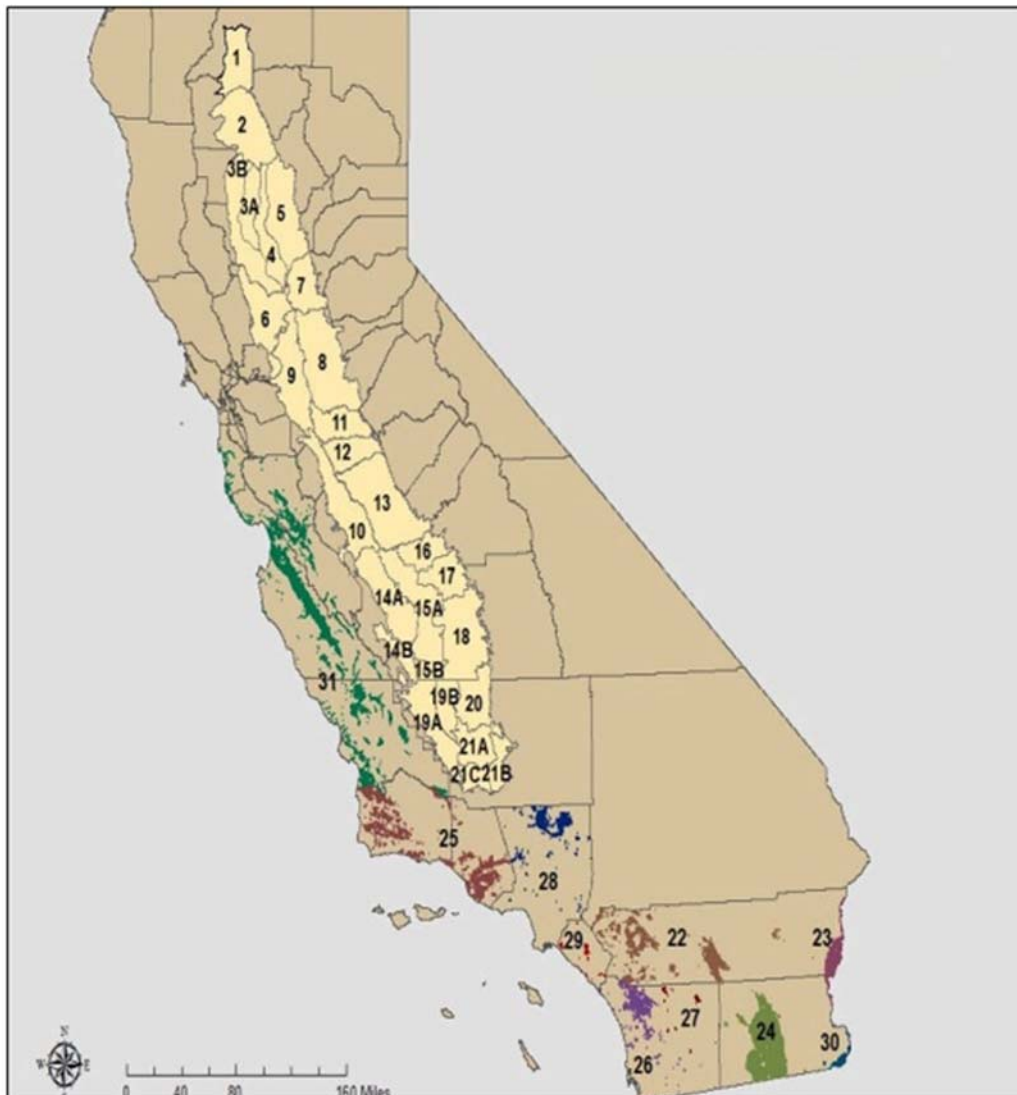
Data Management

All input and output data are stored locally. Some of SWAP input data are based on field and market information (e.g. crop yield, Ag water use efficiency, crop prices, and cost of water). Other inputs come from the result of other models like CALSIM to provide information on amount water supply available for Ag from SWP and CVP projects.

Software

SWAP operates using the General Algebraic Modeling System (GAMS) software. GAMS software is available from GAMS Development Corp., 1217 Potomac Street, N.W., Washington, and D.C 20007, U.S.A. This software is available for Window based personal computers and a variety of workstations or larger computers. The SWAP code is public domain and portable across all of these platforms.

Figure 1. SWAP Coverage of Agriculture in California



20 Proxy Crops used in SWAP Model

- Almonds
- Alfalfa Hay
- Corn
- Cotton, Upland and/or Pima
- Summer Squash/Squash
- Dry Beans
- Fresh Tomatoes
- Wheat
- Onions
- Walnuts

- Sudan Grass, Hay
- Broccoli
- Pasture
- Potato
- Processing Tomatoes
- Rice
- Safflower
- Sugar Beets
- Oranges, Navel and/or Valencia
- Vineyards, Grapes Wine, Table Grapes, Raisin Grapes